

## ACM NG-2005

# Appendix NG - Standard Procedure for Determining the Seasonal Energy Efficiencies of Single-Zone Nonresidential Air Distribution Systems in Buffer Spaces or Outdoors~~the Space Between an Insulated Ceiling and the Roof~~

### **NG.1 Purpose and Scope**

ACM NG contains procedures for measuring the air leakage in single zone, nonresidential air distribution systems and for calculating the annual and hourly duct system efficiency for energy calculations. The methods described here apply to single zone, constant volume heating and air conditioning systems serving zones with 5000 ft<sup>2</sup> of floor area or less, with duct systems located in unconditioned or semi-conditioned buffer spaces or outdoors. These calculations apply to new buildings or new air conditioning systems applied to existing buildings.

## **NG.1 Introduction**

~~This appendix describes the measurement and calculation methods for determining air distribution system efficiency for single-zone non-residential air distribution systems in the space between an insulated ceiling and the roof.~~

### **NG.2 Definitions**

**aerosol sealant closure system:** A method of sealing leaks by blowing aerosolized sealant particles into the duct system ~~and~~ which must include minute-by-minute documentation of the sealing process.

**buffer space:** an unconditioned or indirectly conditioned space located between a ceiling and the roof.

~~**floor area** :The floor area of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces enclosing the conditioned space.~~

**cool roof**:- a roofing material with high thermal emittance and high solar reflectance, or lower thermal emittance and exceptionally high solar reflectance as specified in Standards § 118 (i) that reduces heat gain through the roof.

**delivery effectiveness**:-\_The ratio of the thermal energy delivered to the conditioned space and the thermal energy entering the distribution system at the equipment heat exchanger.

**distribution system efficiency**:-\_The ratio of the thermal energy consumed by the equipment with the distribution system to the energy consumed if the distribution system had no losses or impact on the equipment or building loads.

**equipment efficiency**:-\_The ratio between the thermal energy entering the distribution system at the equipment heat exchanger and the energy being consumed by the equipment.

**equipment factor** :  $F_{\text{equip}}$  is the ratio of the equipment efficiency including the effects of the distribution system to the equipment efficiency of the equipment in isolation.

**fan flowmeter device**: A device used to measure air flow rates under a range of test pressure differences.

**floor area**: The floor area of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces enclosing the conditioned space.

**Flow capture hood**: A device used to capture and measure the airflow at a register.

**load factor** :  $F_{\text{load}}$  is the ratio of the building energy load without including distribution effects to the load including distribution system effects.

**pressure pan** : a device used to seal individual forced air system registers and to measure the static pressure from the register.

~~**radiant barrier** : a surface of low emissivity (less than 0.05) placed inside an attic or roof space to reduce radiant heat transfer.~~

**recovery factor** :  $F_{\text{recov}}$  is the fraction of energy lost from the distribution system that enters the conditioned space.

**thermal regain**: The fraction of delivery system losses that are returned to the building.

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### NG.3 Nomenclature

$a_r$  = duct leakage factor (1-return leakage) for return ducts

$a_s$  = duct leakage factor (1-supply leakage) for supply ducts

$A_{duct,buffer}$  = total supply plus return duct area in buffer space, ft<sup>2</sup>

$A_{duct,outdoor}$  = total supply plus return duct area located outdoors, ft<sup>2</sup>

$A_{duct,n}$  = total supply plus return duct area in space n, ft<sup>2</sup>

$A_{floor}$  = conditioned floor area of building, ft<sup>2</sup>

~~$A_{r,out}$  = surface area of return duct outside conditioned space, ft<sup>2</sup>~~

$A_{r,buffer}$  = return duct surface area in buffer space, ft<sup>2</sup>

$A_{r,total}$  = total return duct surface area, ft<sup>2</sup>

$A_{r,attic}$  = return duct area in attic, ft<sup>2</sup>

$A_{r,base}$  = return duct area in basement, ft<sup>2</sup>

$A_{r,crawl}$  = return duct area in crawlspace, ft<sup>2</sup>

$A_{r,gar}$  = return duct area inside garage, ft<sup>2</sup>

~~$A_{s,out}$  = surface area of supply duct outside conditioned space, ft<sup>2</sup>~~

$A_{s,buffer}$  = supply duct surface area in buffer space, ft<sup>2</sup>

$A_{s,total}$  = total supply duct surface area, ft<sup>2</sup>

$A_{s,attic}$  = supply duct area in attic, ft<sup>2</sup>

$A_{s,base}$  = supply duct area in basement, ft<sup>2</sup>

$A_{s,crawl}$  = supply duct area in crawlspace, ft<sup>2</sup>

$A_{s,gar}$  = supply duct area inside garage, ft<sup>2</sup>

~~$A_{s,in}$  = supply duct area inside conditioned space, ft<sup>2</sup>~~

$A_{walls}$  = area of buffer space exterior walls, ft<sup>2</sup>

$A_{roof}$  = area of buffer space roof, ft<sup>2</sup>

$B_r$  = conduction fraction for return

$B_s$  = conduction fraction for supply

$C_p$  = specific heat of air = 0.24 Btu/(lb·°F)

$C_{DT}, C_{Dh}, C_{R}, C_L$  = regression coefficients for hourly model

DE = delivery effectiveness

~~DE<sub>design</sub> = design delivery effectiveness~~

DE<sub>seasonal</sub> = seasonal delivery effectiveness

E<sub>equip</sub> = rate of energy exchanged between equipment and delivery system, Btu/hour

$E_{hr}$  = hourly HVAC system energy input (kW for electricity, therms for gas)

F<sub>cycloss</sub> = cyclic loss factor

$F_{\text{equip}}$  = load factor for equipment

~~$F_{\text{flow}}$  = load factor for fan flow effect on equipment efficiency~~

$F_{\text{leak}}$  = fraction of system fan flow that leaks out of supply or return ducts

$F_{\text{load}}$  = load factor for delivery system

$F_{\text{recov}}$  = thermal loss recovery factor

$F_{\text{regain}}$  = thermal regain factor

$h_o$  = outside roof surface convection coefficient, = 3.4 Btu/hr ft<sup>2</sup>°F

$I_{\text{hor}}$  = global solar radiation on horizontal surface, Btu/hr ft<sup>2</sup>

$K_r$  = return duct surface area coefficient

$K_s$  = supply duct surface area coefficient

$N_{\text{story}}$  = number of stories of the building

$P_{\text{sp}}$  = pressure difference between supply plenum and conditioned space [Pa]

$P_{\text{test}}$  = test pressure for duct leakage [Pa]

$Q_{\text{buffer}}$  = buffer space infiltration rate, cfm

~~$Q_e$  = Flow through air handler fan at operating conditions, cfm~~  
 $Q_e$  = Flow through air handler at 400 cfm/rated ton with rated tons defined by unit scheduled capacity at the conditions the unit's ARI rating standard from Section 112 of the Standard. Airflow through heating only furnaces shall be based on a 21.7 cfm/kBtuh rated output capacity.

$Q_{\text{total},25}$  = total duct leakage at 25 Pascal, cfm

$R_r$  = thermal resistance of return duct, h ft<sup>2</sup>°F/Btu

$R_s$  = thermal resistance of supply duct, h ft<sup>2</sup>°F/Btu

$T_{\text{amb,cool}}$  = cooling season ambient temperature, °F

$T_{\text{amb,heat}}$  = heating season ambient temperature, °F

$T_{\text{amb},r}$  = ambient temperature for return-, °F

$T_{\text{amb},s}$  = ambient temperature for supply-, °F

~~$T_{\text{attic}}$  = attic air temperature, °F~~

~~$T_{\text{base}}$  = return duct temperature in basement, °F~~

~~$T_{\text{crawl}}$  = return duct temperature in crawlspace, °F~~

~~$T_{\text{design}}$  = outdoor air design temperature, °F~~

~~$T_{\text{ground}}$  = ground temperature, °F~~

~~$T_{\text{gar}}$  = temperature of garage air, °F~~

$T_{\text{in}}$  = temperature of indoor air-, °F

~~$T_{\text{rp}}$  = return plenum air temperature, °F~~

~~$T_{\text{seasonal}}$  = outdoor air seasonal temperature, °F~~

$T_{\text{solair}}$  = sol-air temperature, °F

$T_{\text{sp}}$  = supply plenum air temperature-, °F

$UA_c$  = UA value for the interface between the conditioned space and the buffer space, Btu/°F

$UA_{\text{walls}}$  = UA value for the buffer space exterior walls, Btu/°F

$UA_{\text{roof}}$  = UA value for the buffer space exterior roof, Btu/°F

$UA_c$  = UA value for the interface between the conditioned space and the buffer space, Btu/°F

$ZLC_c$  = zone loss coefficient for the interface between the conditioned space and the buffer space, Btu/°F

$ZLC_{\text{total}}$  = sum of all the zone loss coefficients for the buffer space, Btu/°F

$\alpha$  = solar absorptivity of roof, = 0.70 for standard roof; 0.45 for cool roof, 0.0 for ducts located outdoors

$\Delta T_e$  = temperature rise across heat exchanger, °F

$\Delta T_r$  = temperature difference between indoors and the ambient for the return, °F

$\Delta T_s$  = temperature difference between indoors and the ambient for the supply, °F

$\Delta T_{\text{sky}}$  = reduction of sol-air temperature due to sky radiation, = 6.5°F for standard roof and cool roof, 0.0°F for ducts located outdoors, °F.

$\Delta T_{\text{sol,hr}}$  = hourly difference between sol-air and indoor temperatures, °F

$\Delta T_{\text{sol, season}}$  = energy weighted seasonal average difference between sol-air and indoor temperatures, °F

$h_{\text{adj,hr}}$  = hourly distribution efficiency adjustment factor

$\eta_{\text{dist,seasonal}}$  = seasonal distribution system efficiency

$h_{\text{dist,hr}}$  = hourly distribution system efficiency

$\rho$  = density of air = 0.075, lb/ft<sup>3</sup>

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## **NG.4 Air Distribution Diagnostic Measurement and Default Assumptions**

### **NG.4.1 Instrumentation Specifications**

The instrumentation for the air distribution diagnostic measurements shall conform to the following specifications:

#### **NG.4.1.1 Pressure Measurements**

All pressure measurements shall be measured with measurement systems (i.e. sensor plus data acquisition system) having an accuracy of  $\pm 0.2$  Pa. All pressure measurements within the duct system shall be made with static pressure probes.

#### **NG.4.1.2 Fan Flow Measurements**

~~All measurements of distribution fan flows shall be made with measurement systems (i.e. sensor plus data acquisition system) having an accuracy of  $\pm 5\%$  reading or  $\pm 5$  cfm whichever is greater.~~

#### **NG.4.1.23 Duct Leakage Measurements**

The measurement of air flows during duct leakage testing shall have an accuracy of  $\pm 3\%$  of measured flow using digital gauges.

All instrumentation used for ~~fan flow and~~ duct leakage diagnostic measurements shall be calibrated according to the manufacturer's calibration procedure to conform to the above accuracy requirement. All testers performing diagnostic tests shall obtain evidence from the manufacturer that the equipment meets the accuracy specifications. The evidence shall include equipment model, serial number, the name and signature of the person of the test laboratory verifying the accuracy, and the instrument accuracy. All diagnostic testing equipment is subject to re-calibration when the period of the manufacturer's guaranteed accuracy expires.

### **NG.4.2 Apparatus**

#### **NG.4.2.1 Duct Leakage Pressurization**

The apparatus for fan pressurization duct leakage measurements shall consist of a duct pressurization and flow measurement device meeting the specifications in Section NG.4.1.23.

### **NG.4.3 Procedure**

The following sections identify input values for building and HVAC system (including ducts) using either default or diagnostic information.

#### **NG.4.3.1 Building Information and Defaults**

The calculation procedure for determining air distribution efficiencies requires the following building information:

1. climate zone for the building,
2. conditioned floor area, ~~and~~
3. number of stories,
4. areas and U-values of surfaces enclosing space between the roof and a ceiling, and
5. surface area of ductwork if ducts are located outdoors or in multiple spaces.

**NG.4.3.1.1 Default Input**

Using default values rather than diagnostic procedures produce relatively low air distribution-system efficiencies.

Default values shall be obtained from following sections:

1. the location of the duct system in Section NG.4.3.4,
2. the surface area and insulation level of the ducts in Sections NG.4.3.3, NG.4.3.4 and ~~(NG)~~4.3.6,
3. the system fan flow in Section NG.4.3.7, and
4. the leakage of the duct system in Section NG.4.3.8.

**NG.4.3.2 Diagnostic Input**

Diagnostic inputs are used for the calculation of improved duct efficiency. The diagnostics include observation of various duct characteristics and measurement of duct leakage and system fan flows as described in Sections NG.4.3.5 through NG.4.3.8. These observations and measurements replace those assumed as default values.

The diagnostic procedures include:

- ~~M~~measurement of total duct system leakage as described in Section NG.4.3.8.
- ~~Measurement of duct surface area if ducts are located outdoors or in multiple spaces~~ as described in Section 4.3.3.
- ~~Observe~~ Observation of the insulation level for the supply ( $R_s$ ) and return ( $R_r$ ) ducts outside the conditioned space as described in Section NG.4.3.6.
- ~~Observe~~ation of the presence of a cool roof.
- Observation of ~~the~~ presence of an outdoor air economizer.

**NG.4.3.3 Duct Surface Area**

The supply-side and return-side duct surface areas shall be calculated separately. If the supply or return duct is located in more than one ~~zonespace~~, the area of that duct in each ~~zonespace~~ shall ~~may~~ be calculated separately. ~~The duct surface area shall be determined using one of the following methods.~~

**NG.4.3.3.1 Default Duct Surface Area**

The default duct surface area for supply and return shall be calculated as follows:

For supplies:

Equation NG-1  $A_{s,total} = K_s A_{floor}$

Where  $K_s$  (supply duct surface area coefficient) shall be ~~1-0.25~~ for ~~systems serving the top one story buildings only~~, 0.125 for ~~systems serving the top story plus one other two-story buildings~~, and 0.0833 for ~~systems serving three or more stories~~ ~~story buildings~~.

For returns:

Equation NG-2  $A_{r,total} = K_r A_{floor}$

Where  $K_r$  (return duct surface area coefficient) shall be 0.105 for systems serving the top story only, 0.125 for systems serving the top story plus one other, and 0.08 for systems serving three or more stories, ~~for one story building and 0.1 for two or more stories.~~

If ducts are located outdoors, the outdoor duct surface area shall be calculated from the duct layout on the plans using measured duct lengths and nominal inside diameters (for round ducts) or inside perimeters (for rectangular ducts) of each outdoor duct run in the building that is within the scope of the calculation procedure. When using the default duct area, outdoor supply duct surface area shall be less than or equal to the default supply duct surface area; outdoor return duct surface area shall be less than or equal to the default return duct surface area.

The surface area of ducts located in the buffer space between ceilings and roofs shall be calculated from:

Equation NG-3 
$$A_{s,buffer} = A_{s,total} - A_{s,outdoors}$$

Equation NG-4 
$$A_{r,buffer} = A_{r,total} - A_{r,outdoors}$$

#### NG4.3.3.2 Measured Duct Surface Area

Measured duct surface areas shall be used when the outdoor duct surface area measured from the plans is greater than default duct surface area for either supply ducts or return ducts. If a duct system passes through multiple spaces that have different ambient temperature conditions as specified in Section 4.3.5, the duct surface area shall be measured for each space individually. The duct surface area shall be calculated from measured duct lengths and nominal inside diameters (for round ducts) or inside perimeters (for rectangular ducts) of each duct run located in buffer spaces or outdoors.

#### **NG.4.3.4 Duct Location**

Duct systems covered by this procedure are those specified in the Standards § 144(k)3.

~~Ducts shall be considered to be installed in spaces between ceilings and roofs or building exteriors if more than 50 lineal feet of duct or 75 percent of the duct surface area is located in a space between an insulated ceiling and the roof, and that space is either a) vented to the outdoors, and/or b) insulated from the indoors.~~

#### **NG.4.3.5 Climate and Duct Ambient Conditions for Ducts in the Space Between an Insulated Ceiling and the Roof**

Duct ambient temperatures for both heating and cooling shall be obtained from Tables NG-1a to NG-1e. The duct ambient temperatures for the cool roofs from Table NG-1c shall be used for ducts located in unconditioned spaces other than attics and outside. Indoor dry-bulb ( $T_{in}$ ) temperature for cooling is 78°F. The indoor dry-bulb temperature for heating is 70°F.



**Table NG-1a** ~~Default Assumptions for Duct Ceiling/Roof Space Ambient Temperature, Ceiling Insulation, No roof insulation, Non-vented Attic~~

**~~TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.~~**

Climate zone	Duct Ambient Temperature for Heating, <u>T amb, heat</u> <del>T heat, amb</del>	Duct Ambient Temperature for Cooling, <u>T amb, cool</u> <u>Standard roof without economizer</u> <del>T cool, amb</del>	Duct Ambient Temperature for Cooling, <u>T amb, cool</u> <u>Cool roof without economizer</u>	Duct Ambient Temperature for Cooling, <u>T amb, cool</u> <u>Standard roof with economizer</u>	Duct Ambient Temperature for Cooling, <u>T amb, cool</u> <u>Cool roof with economizer</u>
1	<u>47.352.0</u>	<u>78.060.0</u>	<u>72.4</u>	<u>81.4</u>	<u>75.3</u>
2	<u>41.848.0</u>	<u>93.287.0</u>	<u>84.8</u>	<u>97.1</u>	<u>88.2</u>
3	<u>47.855.0</u>	<u>83.580.0</u>	<u>77.1</u>	<u>86.6</u>	<u>79.8</u>
4	<u>43.953.0</u>	<u>89.179.0</u>	<u>82.0</u>	<u>92.0</u>	<u>84.5</u>
5	<u>46.249.0</u>	<u>83.874.0</u>	<u>77.5</u>	<u>86.0</u>	<u>79.3</u>
6	<u>50.857.0</u>	<u>85.481.0</u>	<u>79.4</u>	<u>87.3</u>	<u>81.1</u>
7	<u>49.362.0</u>	<u>86.874.0</u>	<u>80.7</u>	<u>88.7</u>	<u>82.3</u>
8	<u>47.358.0</u>	<u>91.380.0</u>	<u>84.2</u>	<u>93.1</u>	<u>85.9</u>
9	<u>48.753.0</u>	<u>92.587.0</u>	<u>85.4</u>	<u>94.4</u>	<u>87.2</u>
10	<u>45.753.0</u>	<u>95.991.0</u>	<u>87.9</u>	<u>98.2</u>	<u>90.0</u>
11	<u>43.948.0</u>	<u>95.595.0</u>	<u>88.1</u>	<u>98.4</u>	<u>90.5</u>
12	<u>44.250.0</u>	<u>94.391.0</u>	<u>86.7</u>	<u>97.3</u>	<u>89.3</u>
13	<u>43.348.0</u>	<u>100.992.0</u>	<u>92.5</u>	<u>103.6</u>	<u>94.9</u>
14	<u>37.239.0</u>	<u>99.099.0</u>	<u>90.6</u>	<u>102.7</u>	<u>93.8</u>
15	<u>47.250.0</u>	<u>102.940.2</u>	<u>95.8</u>	<u>104.3</u>	<u>97.1</u>
16	<u>37.932.0</u>	<u>92.080.0</u>	<u>83.8</u>	<u>96.3</u>	<u>87.5</u>

*Table NG-1b Default Assumptions for Duct Ceiling/Roof Space Ambient Temperature, Ceiling Insulation, No roof insulation, Vented Attic*

**~~TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.~~**

<u>Climate zone</u>	<u>Duct Ambient Temperature for Heating,</u> $T_{amb, heat}$	<u>Duct Ambient Temperature for Cooling,</u> $T_{amb, cool}$ <u>Standard roof without economizer</u>	<u>Duct Ambient Temperature for Cooling,</u> $T_{amb, cool}$ <u>Cool roof without economizer</u>	<u>Duct Ambient Temperature for Cooling, <math>T_{amb, cool}</math></u> <u>Standard roof with economizer</u>	<u>Duct Ambient Temperature for Cooling,</u> $T_{amb, cool}$ <u>Cool roof with economizer</u>
<u>1</u>	<u>48.6</u>	<u>73.7</u>	<u>69.8</u>	<u>76.7</u>	<u>72.5</u>
<u>2</u>	<u>43.4</u>	<u>87.9</u>	<u>82.2</u>	<u>91.7</u>	<u>85.7</u>
<u>3</u>	<u>48.9</u>	<u>79.2</u>	<u>74.8</u>	<u>82.1</u>	<u>77.4</u>
<u>4</u>	<u>45.1</u>	<u>84.4</u>	<u>79.5</u>	<u>87.1</u>	<u>81.9</u>
<u>5</u>	<u>47.7</u>	<u>79.7</u>	<u>75.4</u>	<u>81.9</u>	<u>77.3</u>
<u>6</u>	<u>51.8</u>	<u>81.0</u>	<u>76.8</u>	<u>81.0</u>	<u>78.5</u>
<u>7</u>	<u>50.6</u>	<u>82.4</u>	<u>78.1</u>	<u>84.1</u>	<u>79.7</u>
<u>8</u>	<u>48.7</u>	<u>86.4</u>	<u>81.5</u>	<u>88.2</u>	<u>83.2</u>
<u>9</u>	<u>49.3</u>	<u>88.4</u>	<u>83.4</u>	<u>90.2</u>	<u>85.1</u>
<u>10</u>	<u>47.1</u>	<u>90.9</u>	<u>85.4</u>	<u>93.2</u>	<u>87.6</u>
<u>11</u>	<u>44.8</u>	<u>90.9</u>	<u>85.8</u>	<u>93.7</u>	<u>88.3</u>
<u>12</u>	<u>45.2</u>	<u>89.6</u>	<u>84.4</u>	<u>92.5</u>	<u>87.0</u>
<u>13</u>	<u>44.5</u>	<u>95.1</u>	<u>89.3</u>	<u>97.7</u>	<u>91.7</u>
<u>14</u>	<u>38.6</u>	<u>93.7</u>	<u>87.8</u>	<u>97.2</u>	<u>91.0</u>
<u>15</u>	<u>48.4</u>	<u>98.6</u>	<u>93.7</u>	<u>100.1</u>	<u>95.1</u>
<u>16</u>	<u>38.7</u>	<u>86.9</u>	<u>81.1</u>	<u>91.1</u>	<u>84.9</u>

*Table NG-1c Default Assumptions for Duct Ceiling/Roof Space Ambient Temperature, Ceiling Insulation, Roof insulation, Non-vented Attic*

**~~TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.~~**

<u>Climate zone</u>	<u>Duct Ambient Temperature for Heating.</u> $T_{amb, heat}$	<u>Duct Ambient Temperature for Cooling.</u> $T_{amb, cool}$ <u>Standard roof without economizer</u>	<u>Duct Ambient Temperature for Cooling.</u> $T_{amb, cool}$ <u>Cool roof without economizer</u>	<u>Duct Ambient Temperature for Cooling.</u> $T_{amb, cool}$ <u>Standard roof with economizer</u>	<u>Duct Ambient Temperature for Cooling.</u> $T_{amb, cool}$ <u>Cool roof with economizer</u>
<u>1</u>	<u>56.4</u>	<u>77.6</u>	<u>74.8</u>	<u>79.9</u>	<u>76.9</u>
<u>2</u>	<u>54.8</u>	<u>86.9</u>	<u>82.8</u>	<u>89.7</u>	<u>85.4</u>
<u>3</u>	<u>56.4</u>	<u>81.1</u>	<u>77.9</u>	<u>83.3</u>	<u>79.9</u>
<u>4</u>	<u>54.6</u>	<u>84.9</u>	<u>81.3</u>	<u>87.0</u>	<u>83.3</u>
<u>5</u>	<u>56.6</u>	<u>81.3</u>	<u>78.2</u>	<u>82.9</u>	<u>79.6</u>
<u>6</u>	<u>57.1</u>	<u>83.9</u>	<u>80.1</u>	<u>85.5</u>	<u>81.6</u>
<u>7</u>	<u>55.7</u>	<u>84.9</u>	<u>81.1</u>	<u>86.5</u>	<u>82.5</u>
<u>8</u>	<u>54.5</u>	<u>88.0</u>	<u>83.6</u>	<u>89.5</u>	<u>85.0</u>
<u>9</u>	<u>59.9</u>	<u>83.6</u>	<u>81.6</u>	<u>84.2</u>	<u>82.1</u>
<u>10</u>	<u>55.9</u>	<u>89.4</u>	<u>85.6</u>	<u>91.2</u>	<u>87.2</u>
<u>11</u>	<u>53.1</u>	<u>89.7</u>	<u>86.1</u>	<u>91.8</u>	<u>87.9</u>
<u>12</u>	<u>53.7</u>	<u>88.7</u>	<u>84.8</u>	<u>90.9</u>	<u>86.8</u>
<u>13</u>	<u>53.6</u>	<u>93.1</u>	<u>89.0</u>	<u>95.2</u>	<u>90.9</u>
<u>14</u>	<u>48.7</u>	<u>91.9</u>	<u>87.6</u>	<u>94.7</u>	<u>90.1</u>
<u>15</u>	<u>56.1</u>	<u>95.9</u>	<u>92.3</u>	<u>97.0</u>	<u>93.4</u>
<u>16</u>	<u>48.5</u>	<u>86.6</u>	<u>82.4</u>	<u>89.6</u>	<u>85.1</u>

*Table NG-1d Default Assumptions for Duct Ceiling/Roof Space Ambient Temperature, Roof Insulation, No Ceiling Insulation, Non-vented Attic*

**TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.**

<u>Climate zone</u>	<u>Duct Ambient Temperature for Heating,</u> $T_{amb, heat}$	<u>Duct Ambient Temperature for Cooling,</u> $T_{amb, cool}$ <u>Standard roof without economizer</u>	<u>Duct Ambient Temperature for Cooling,</u> $T_{amb, cool}$ <u>Cool roof without economizer</u>	<u>Duct Ambient Temperature for Cooling, <math>T_{amb, cool}</math></u> <u>Standard roof with economizer</u>	<u>Duct Ambient Temperature for Cooling,</u> $T_{amb, cool}$ <u>Cool roof with economizer</u>
<u>1</u>	<u>59.8</u>	<u>78.5</u>	<u>77.3</u>	<u>79.3</u>	<u>78.0</u>
<u>2</u>	<u>59.0</u>	<u>82.5</u>	<u>80.8</u>	<u>83.5</u>	<u>81.6</u>
<u>3</u>	<u>60.1</u>	<u>80.0</u>	<u>78.6</u>	<u>80.7</u>	<u>79.3</u>
<u>4</u>	<u>58.9</u>	<u>81.6</u>	<u>80.1</u>	<u>82.3</u>	<u>80.7</u>
<u>5</u>	<u>60.0</u>	<u>80.0</u>	<u>78.6</u>	<u>80.6</u>	<u>79.1</u>
<u>6</u>	<u>60.4</u>	<u>81.2</u>	<u>79.5</u>	<u>81.8</u>	<u>80.0</u>
<u>7</u>	<u>59.7</u>	<u>81.7</u>	<u>79.9</u>	<u>82.2</u>	<u>80.5</u>
<u>8</u>	<u>58.8</u>	<u>83.1</u>	<u>81.1</u>	<u>83.7</u>	<u>81.7</u>
<u>9</u>	<u>59.9</u>	<u>83.6</u>	<u>81.6</u>	<u>84.2</u>	<u>82.1</u>
<u>10</u>	<u>58.5</u>	<u>83.4</u>	<u>81.8</u>	<u>84.0</u>	<u>82.3</u>
<u>11</u>	<u>58.5</u>	<u>83.7</u>	<u>82.1</u>	<u>84.3</u>	<u>82.7</u>
<u>12</u>	<u>58.3</u>	<u>83.2</u>	<u>81.6</u>	<u>83.8</u>	<u>82.1</u>
<u>13</u>	<u>58.3</u>	<u>85.1</u>	<u>83.3</u>	<u>85.7</u>	<u>83.9</u>
<u>14</u>	<u>54.5</u>	<u>84.5</u>	<u>82.8</u>	<u>85.4</u>	<u>83.5</u>
<u>15</u>	<u>58.6</u>	<u>86.1</u>	<u>84.6</u>	<u>86.5</u>	<u>84.9</u>
<u>16</u>	<u>55.6</u>	<u>82.4</u>	<u>80.7</u>	<u>83.4</u>	<u>81.5</u>

*Table NG-1e Default Assumptions for Duct Ambient Temperature, Ducts Located Outdoors***TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.**

Climate zone	Duct Ambient Temperature for Heating, $T_{amb\_heat}$	Duct Ambient Temperature for Cooling, $T_{amb\_cool}$ Without economizer	Duct Ambient Temperature for Cooling, $T_{amb\_cool}$ With economizer
1	47.7	62.7	65.4
2	42.5	76.0	79.7
3	47.6	68.5	71.3
4	43.5	73.3	75.8
5	47.1	69.5	71.7
6	50.7	70.0	71.8
7	50.2	71.6	73.2
8	48.3	74.6	76.4
9	47.0	78.1	80.0
10	46.7	79.9	82.1
11	42.8	81.3	83.8
12	43.4	79.4	82.0
13	43.0	83.2	85.4
14	36.4	81.8	85.1
15	48.1	90.7	92.2
16	35.7	73.5	78.1

**NG.4.3.6 Duct Wall Thermal Resistance****NG.4.3.6.1 Default Duct Insulation R value**

Default duct wall thermal resistance for new buildings is R-8.04-2, the mandatory requirement for ducts installed in newly constructed buildings, additions and new or replacement ducts installed in existing buildings. ~~Default duct wall thermal resistance for existing ducts in existing buildings is R-4.0.~~ An air film resistance of 0.7 [h ft<sup>2</sup> °F/BTU] shall be added to the duct insulation R value to account for external and internal film resistance.

**NG.4.3.6.2 Diagnostic Duct Wall Thermal Resistance**

Duct wall thermal resistance shall be determined from the manufacturer's specification observed during diagnostic inspection. If ducts with multiple R values are installed, the lowest duct R value shall be used. If a duct with a higher R value than 8.04-2 is installed, the R-value shall be clearly stated on the building plans and a visual inspection of the ducts must be performed to verify the insulation values. ~~In case the space on top of the duct boot is limited and can not be inspected, the insulation R value within two feet of the boot to which the duct is connected may be excluded from the determination of the overall system R value.~~

**NG.4.3.7 System Total Fan Flow****NG.4.3.7.1 Default Fan Flow**

The ~~default cooling total fan flow with for an air conditioner and for heating with or a heat pump for~~ **all climate zones** shall be calculated as follows:

$$Q_e = 1.25 A_{\text{floor}} \quad (4.3)$$

equal to 400 cfm/rated ton with rated tons defined by unit scheduled capacity at the conditions the unit's ARI rating standard from Section 112 of the Standard. Airflow through heating only furnaces shall be based on 21.7 cfm/kBtuh rated output capacity.

### **NG.4.3.8 Duct Leakage**

#### *NG.4.3.8.1 Duct Leakage Factor for Delivery Effectiveness Calculations*

Default duct leakage factors for the Proposed Design shall be obtained from Table NG-2, using the "not Tested" values.

Duct leakage factors for the Standard Design shall be obtained from Table NG-2, using the appropriate "Tested" value.

Duct leakage factors shown in Table NG-2 shall be used in calculations of delivery effectiveness.

*Table NG-2 Duct Leakage Factors*

	<del>Duct Leakage Diagnostic Test Performed using Section 4.3.8.2 Procedures</del>	as = ar =
<del>Untested</del> Duct systems in buildings built prior to <del>June 1, 2004</del>	Not tested	0.86
<del>Untested</del> Duct systems in buildings built after <del>(June 2, 2004)</del>	Not tested	0.8289
Duct systems in buildings of all ages, —System tested after HVAC system completion	<del>(Q<sub>total</sub> / 25) Total leakage is less than 0.06 Q<sub>e</sub></del>	0.96
Sealed and tested duct systems in existing buildings, —System tested after HVAC equipment and/or duct installation		0.915
Sealed and tested duct systems in new buildings duct systems, —System tested after HVAC system installation	<del>(Q<sub>total</sub> / 25) Total leakage is less than 0.06 Q<sub>e</sub></del>	0.96

#### *NG.4.3.8.2 Diagnostic Duct Leakage*

**~~Diagnostic duct leakage measurement is used to quantify total leakage for the calculation of air distribution efficiency. To obtain the improved duct efficiency for sealing the duct system, a diagnostic leakage test as described in section NG.4.3.8.2.1 or NG.4.3.8.2.2 must be performed.~~**

Diagnostic duct leakage measurement is used by installers and raters to verify that total leakage meets the criteria for any sealed duct system specified in the compliance documents. Table NG-3 shows the leakage criteria and test procedures that may be used to demonstrate compliance. In addition to the minimum tests shown, existing duct systems may be tested to show they comply with the criteria for new duct systems.

Table NG-3 Duct Leakage Tests

<u>Case</u>	<u>User and Application</u>	<u>Leakage criteria, % of total fan flow</u>	<u>Procedure</u>
<u>Sealed and tested new duct systems</u>	<u>Installer Testing</u> <u>HERS Rater Testing</u>	<u>6%</u>	<u>NG 4.3.8.2.1</u>
<u>Sealed and tested altered existing duct systems</u>	<u>Installer Testing</u> <u>HERS Rater Testing</u>	<u>15% Total Duct Leakage</u>	<u>NG 4.3.8.2.1</u>
	<u>Installer Testing and Inspection</u> <u>HERS Rater Testing and Verification</u>	<u>60% Reduction in Leakage and Visual Inspection</u>	<u>NG 4.3.8.2.2</u> <u>(RC4.3.6 and RC4.3.7)</u>
	<u>Installer Testing and Inspection</u> <u>HERS Rater Testing and Verification</u>	<u>Fails Leakage Test but All Accessible Ducts are Sealed And Visual Inspection</u>	<u>NG 4.3.8.2.3</u> <u>RC4.3.6 and RC4.3.7</u>

NG.4.3.8.2.1 Diagnostic Total Duct Leakage Test from Fan Pressurization of Ducts

The objective of this procedure is for an installer to determine or a rater to verify the total leakage of a new or altered duct system. The total duct leakage shall be determined by pressurizing both the supply and return ducts to 25 Pascals with all ceiling diffusers/grilles and HVAC equipment installed. When existing ducts are to be altered, this test shall be performed prior to and after duct sealing. The following procedure shall be used for the fan pressurization tests:

1. Verify that the air handler, supply and return plenums and all the connectors, transition pieces, duct boots and registers are installed. The entire system shall be included in the test.
2. For newly installed or altered ducts, verify that cloth backed rubber adhesive duct tape has not been used.
3. Seal all the supply and return registers, except for one return register or the system fan access. Verify that all outside air dampers and /or economizers are sealed prior to pressurizing the system.
2. Attach the fan flowmeter device to the duct system at the unsealed register or access door.
3. Install a static pressure probe at a supply.
4. Adjust the fan flowmeter to produce a 25 Pascal (0.1 in water) pressure difference between the supply duct and the outside or the building space with the entry door open to the outside.
5. Record the flow through the flowmeter ( $Q_{total,25}$ ) - this is the total duct leakage flow at 25 Pascals.
6. Divide the leakage flow by the total fan flow and convert to a percentage. If the leakage flow percentage is less than 6% for new duct systems or less than 15% for altered duct systems, the system passes.

Duct systems that have passed this total leakage test will be sampled by a HERS rater to show compliance.

When the diagnostic leakage test is performed and the measured total duct leakage is less than 6% of the total fan flow, the duct leakage factor shall be 0.96 as shown in Table NG-2.

NG.4.3.8.2.2 Diagnostic Duct Leakage Using An Aerosol Sealant Closure System

Same procedure as for other closure systems.

3NG 4.3.8.2.2 Leakage Improvement from Fan Pressurization of Ducts

For altered existing duct systems which have a higher leakage percentage than the Total Duct leakage criteria in Section NG 4.3.8.2.1, the objective of this test is to show that the original leakage is reduced through duct sealing as specified in Table NG-3. The following procedure shall be used:

1. Use the procedure in NG 4.3.8.2.1 to measure the leakage before commencing duct sealing.
2. After sealing is complete use the same procedure to measure the leakage after duct sealing.
3. Subtract the sealed leakage from the original leakage and divide the remainder by the original leakage. If the leakage reduction is 60% or greater of the original leakage, the system passes.
4. Complete the Visual Inspection specified in NG 4.3.8.2.4.

Duct systems that have passed this leakage reduction test and the visual inspection test will be sampled by a HERS rater to show compliance.

NG 4.3.8.2.3 Sealing of All Accessible Leaks

For altered existing duct systems that do not pass the Total Leakage test (NG 4.3.8.2.1) the objective of this test is to show that all accessible leaks are sealed and that excessively damaged ducts have been replaced. The following procedure shall be used:

1. Complete each of the leakage tests
1. Complete the Visual Inspection as specified in NG 4.3.8.2.4.

All duct systems that could not pass either the total leakage test or the leakage improvement test will be tested by a HERS rater to show compliance. This is a sampling rate of 100%.

NG 4.3.8.2.4 Visual Inspection of Accessible Duct Sealing

For altered existing duct systems that fail to be sealed to 15% of total fan flow, the objective of this inspection is to confirm that all accessible leaks have been sealed and that excessively damaged ducts have been replaced. The following procedure shall be used:

1. Visually inspect to verify that the following locations have been sealed:
  - ~~(Connections)~~ to plenums and other connections to the forced air unit
  - Refrigerant line and other penetrations into the forced air unit
  - Air handler door panel (do not use permanent sealing material, metal tape is acceptable)
  - Register boots sealed to surrounding material
  - Connections between lengths of duct, as well as connections to takeoffs, wyes, tees, and splitter boxes.
2. Visually inspect to verify that portions of the duct system that are excessively damaged have been replaced. Ducts that are considered to be excessively damaged are:
  - Flex ducts with the vapor barrier split or cracked with a total linear split or crack length greater than 12 inches
  - Crushed ducts where cross-sectional area is reduced by 30% or more
  - Metal ducts with rust or corrosion resulting in leaks greater than 2 inches in any dimension
  - Ducts that have been subject to animal infestation resulting in leaks greater than 2 inches in any dimension

NG 4.3.8.4 Labeling requirements for tested systems



A sticker shall be affixed to the exterior (surface) of the air handler access door with the following text in 14 point font:

"The leakage of the air distribution ducts was found to be \_\_\_\_\_ CFM @ 25 Pascals or \_\_\_\_\_ % of total fan flow.

This system (check one):

• Has a leakage rate that is **equal to or lower** than the prescriptive requirement of 6% leakage for new duct systems or 15% leakage for alterations to existing systems. It meets the prescriptive requirements of California Title 24 Energy Efficiency Standards.

• Has a leakage rate **higher than** 6% leakage for new duct systems or 15% leakage for altered existing systems. It does NOT meet the meet or exceed the prescriptive requirements of the Title 24 standards. However, all accessible ducts were sealed.

Signed: \_\_\_\_\_

Print name: \_\_\_\_\_

Print Company Name: \_\_\_\_\_

Print Contractor License No: \_\_\_\_\_

Print Contractor Phone No: \_\_\_\_\_

Y

Do not remove sticker"

#### **NG.4.4 Delivery Effectiveness (DE) Calculations**

Seasonal delivery effectiveness shall be calculated using the seasonal design temperatures from Table NG-1.

##### **NG.4.4.1 Calculation of Duct Zone Temperatures**

The temperatures of the duct zones outside the conditioned space are determined in Section NG.4.3.5 for seasonal conditions for both heating and cooling.

For heating:

Equation NG-5 \_\_\_\_\_  $T_{amb, s} = T_{amb, r} = T_{amb, heat}$

For cooling:

Equation NG-6 \_\_\_\_\_  $T_{amb, s} = T_{amb, r} = T_{amb, cool}$

Where

$T_{amb, heat}$  and  $T_{amb, cool}$  are determined from values in Table NG.4.1.

If the ducts are not all in the same location, the duct ambient temperature for use in the delivery effectiveness and distribution system efficiency calculations shall be determined using an area weighted average of the duct ambient temperatures for heating and (cooling):

$$\text{Equation NG-7 } T_{amb, heat} = \frac{A_{duct, buffer} \times T_{amb, heat, buffer} + A_{duct, outdoors} \times T_{amb, heat, outdoors}}{A_{duct, buffer} + A_{duct, outdoors}}$$

$$\text{Equation NG-8 } T_{\text{amb,cool}} = \frac{A_{\text{duct,buffer}} \times T_{\text{ambcool,buffer}} + A_{\text{duct,outdoors}} \times T_{\text{ambcool,outdoors}}}{A_{\text{duct,buffer}} + A_{\text{duct,outdoors}}}$$

where the buffer space ambient temperature shall correspond to the location yielding the lowest seasonal delivery effectiveness.

Alternatively, the duct ambient temperature for use in the delivery effectiveness and distribution system efficiency calculations can be determined using an area weighted average of the duct zone temperatures for heating and cooling in all spaces:

$$\text{Equation NG-9 } T_{\text{amb,heat}} = \frac{A_{\text{duct},1} \times T_{\text{ambheat},1} + A_{\text{duct},2} \times T_{\text{ambheat},2} + \dots + A_n \times T_{\text{ambheat},n}}{A_{\text{duct},1} + A_{\text{duct},2} + \dots + A_{\text{duct},n}}$$

$$\text{Equation NG-10 } T_{\text{amb,cool}} = \frac{A_{\text{duct},1} \times T_{\text{ambcool},1} + A_{\text{duct},2} \times T_{\text{ambcool},2} + \dots + A_n \times T_{\text{ambcool},n}}{A_{\text{duct},1} + A_{\text{duct},2} + \dots + A_{\text{duct},n}}$$

#### NG.4.4.2 Seasonal Delivery Effectiveness (DE)

The supply and return conduction fractions,  $B_s$  and  $B_r$ , shall be calculated as follows:

$$\text{Equation NG-11 } B_s = \exp\left(\frac{-A_{s,\text{out}}}{1.08 Q_e R_s}\right)$$

$$\text{Equation NG-12 } B_r = \exp\left(\frac{-A_{r,\text{out}}}{1.08 Q_e R_r}\right)$$

The temperature difference across the heat exchanger in the following equation is used:

for heating:

$$\text{Equation NG-13 } \Delta T_e = 55 \quad (4.8)$$

for cooling:

$$\text{Equation NG-14 } \Delta T_e = -20 \quad (4.9)$$

The temperature difference between the building conditioned space and the ambient temperature surrounding the supply,  $\Delta T_s$ , and return,  $\Delta T_r$ , shall be calculated using the indoor and the duct ambient temperatures.

$$\text{Equation NG-15 } \Delta T_s = T_{\text{in}} - T_{\text{amb,s}} \quad (4.10)$$

$$\text{Equation NG-16 } \Delta T_r = T_{\text{in}} - T_{\text{amb,r}} \quad (4.11)$$

The seasonal delivery effectiveness for heating or cooling systems shall be calculated using:

$$\text{Equation NG-17 } DE_{\text{seasonal}} = a_s B_s - a_s B_s (1 - B_{r,r}) \frac{\Delta T_r}{\Delta T_e} - a_s (1 - B_s) \frac{\Delta T_s}{\Delta T_e}$$

### NG.4.5 Seasonal Distribution System Efficiency

Seasonal distribution system efficiency shall be calculated using delivery effectiveness, equipment, load, and recovery factors calculated for seasonal conditions.

#### NG.4.5.1 Equipment Efficiency Factor ( $F_{\text{equip}}$ )

$F_{\text{equip}}$  is 1.

#### NG.4.5.2 Thermal Regain ( $F_{\text{regain}}$ )

The reduction in building load due to regain of duct losses shall be calculated using the thermal regain factor. ~~The default thermal regain factors are provided in Table NG-3.~~

~~Table NG-3 Thermal Regain Factors~~

Supply Duct Location	Thermal Regain Factor [ $F_{\text{regain}}$ ]
Ceiling/Roof Space	0.10

Equation NG-18 
$$F_{\text{regain}} = \frac{ZLC_c}{ZLC_{\text{total}}} -$$

where:

Equation NG-19 
$$ZLC_c = UA_c + 60Q_e(1 - a_r)rCp$$

Equation NG-20 
$$ZLC_{\text{total}} = \sum_{\text{buffer spaces surfaces}} UA + Q_{\text{buffer}} rCp + 60Q_e(1 - a_r)rCp$$

Equation NG-21 
$$UA_{\text{buffer spaces surfaces}} = UA_c + UA_{\text{walls}} + UA_{\text{roof}}$$

Equation NG-22 
$$Q_{\text{buffer}} = 0.038(60)A_{\text{walls}}\rho C_p$$
 for non-vented buffer spaces

Equation NG-23 
$$Q_{\text{buffer}} = 0.25(60)A_{\text{roof}}\rho C_p$$
 for -vented buffer spaces

Thermal regain for ducts located outdoors shall be equal to 0.0. If the ducts are not all in the same location, the regain shall be determined using an area weighted average of the regain for heating and cooling:

Equation NG-24 
$$F_{\text{regain}} = \frac{A_{\text{duct},1} \times F_{\text{regain},1} + A_{\text{duct},2} \times F_{\text{regain},2} + \dots + A_{\text{duct},n} \times F_{\text{regain},n}}{A_{\text{duct},1} + A_{\text{duct},2} + \dots + A_{\text{duct},n}} -$$

#### NG.4.5.3 Recovery Factor ( $F_{\text{recoy}}$ )

The recovery factor,  $F_{\text{recoy}}$ , is calculated based on the thermal regain factor,  $F_{\text{regain}}$ , and the duct losses without return leakage.

Equation NG-25 
$$F_{\text{recov}} = 1 + F_{\text{regain}} \left( \frac{1 - a_s B_s + a_s B_s (1 - B_r) \frac{\Delta T_r}{\Delta T_e} + a_s (1 - B_s) \frac{\Delta T_s}{\Delta T_e}}{DE_{\text{seasonal}}} \right)$$

#### NG.4.5.4 Seasonal Distribution System Efficiency

The seasonal distribution system efficiency shall be calculated using the seasonal delivery effectiveness from section NG.4.4.2, the equipment efficiency factor from section NG.4.5.1, and the recovery factor from section NG.4.5.3. Note that  $DE_{\text{seasonal}}$ ,  $F_{\text{equip}}$ ,  $F_{\text{recov}}$  must be calculated separately for cooling and heating conditions. Distribution system efficiency shall be determined using the following equation:

Equation NG-26 
$$h_{\text{distseasonal}} = 0.98 DE_{\text{seasonal}} F_{\text{equip}} F_{\text{recov}}$$

where 0.98 accounts for the energy losses from heating and cooling the duct thermal mass.

#### NG.4.6 Hourly Distribution System Efficiency

The hourly duct efficiency shall be calculated for each hour using the following equation:

Equation NG-27 
$$h_{\text{disthr}} = \frac{h_{\text{distseasonal}}}{h_{\text{adj,hr}}} \cdot \eta_{\text{dist,hr}} \leq 1$$

where the hourly efficiency is calculated from the seasonal efficiency and an hourly efficiency adjustment factor. The hourly distribution efficiency shall be less than or equal to 1.0. The hourly duct efficiency adjustment factor shall be calculated from the following equation:

Equation NG-28 
$$h_{\text{adj,hr}} = 1 + C_{\text{DT}} \times (\Delta T_{\text{solhr}} - T_{\text{solseason}})$$

where the hourly efficiency adjustment factor is calculated from the difference between the hourly roof sol-air temperature and the hourly indoor temperature; the difference between the seasonal average difference between the roof sol-air temperature and the indoor temperature; and a constant derived from regression analysis.

The hourly difference between the roof sol-air temperature and the indoor temperature shall be calculated from the following equation:

Equation NG-29 
$$\Delta T_{\text{sol,hr}} = T_{\text{solair,hr}} - T_{\text{in,hr}}$$

The seasonal difference between the roof sol-air temperature and the indoor temperature shall be a load-weighted average of the hourly roof sol-air temperature and the indoor temperature, and shall be calculated from the following equation:

Equation NG-30 
$$T_{\text{solseason}} = \frac{\sum_{\text{season}} (T_{\text{solair,hr}} - T_{\text{in,hr}}) E_{\text{hr}}}{\sum_{\text{season}} E_{\text{hr}}}$$

The hourly roof sol-air temperature is a function of the hourly ambient temperature, hourly horizontal solar radiation and the roof surface absorptance; and shall be calculated from the following equation:

Equation NG-31 
$$T_{\text{solair,hr}} = T_{\text{amb,hr}} + \left( \frac{a}{h_o} \right) I_{\text{hor,hr}} - T_{\text{sky}}$$

The hourly efficiency adjustment factor regression coefficient shall be calculated from the following equation:

Equation NG-332 
$$C_{DT} = C_0 + \frac{C_R}{R_s} + C_L Q_{\text{total},25}; C_{DT,\text{cooling}} \geq 0.0; C_{DT,\text{heating}} \leq 0.0$$

where ~~coefficients~~ constants  $C_0$ ,  $C_R$ , and  $C_L$  shall be taken from Table NG-43 according to the season (heating or cooling), and the roof type for ducts in the buffer space (Standard or Cool roof) or duct location (if outdoors). The calculated value of  $C_{DT}$  for cooling shall be greater than or equal to zero, and the calculated value of  $C_{DT}$  for heating shall be less than or equal to zero.

#### **NG.4.6.3 Hourly Efficiency Adjustment Regression Coefficients and Data**

**TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.**

Table NG-43 Coefficients

	Cooling			Heating		
	Standard roof	Cool roof	Outdoors	Standard roof	Cool roof	Outdoors
<u>C<sub>0</sub></u>	<u>0.000486</u>	<u>0.000538</u>	<u>-0.002763</u>	<u>-0.000430</u>	<u>-0.000418</u>	<u>0.000677</u>
<u>C<sub>R</sub></u>	<u>0.002810</u>	<u>0.003207</u>	<u>0.008702</u>	<u>-0.003978</u>	<u>-0.003659</u>	<u>-0.002614</u>
<u>C<sub>L</sub></u>	<u>0.002143</u>	<u>0.003386</u>	<u>0.031009</u>	<u>-0.012079</u>	<u>-0.011277</u>	<u>-0.012190</u>